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⑰ Applicant: SUMITOMO ELECTRIC INDUSTRIES
LIMITED, No. 15, Kitahama 5-chome Higashi-ku,
Osaka-shi Osaka (JP)

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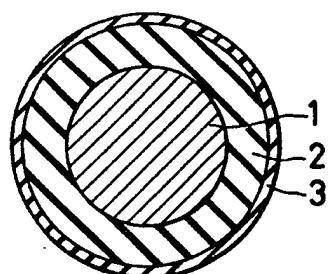
⑰ Inventor: Miyake, Masayoshi, No. 10,
Shinko-dori, 1-chome, Minami-ku Nagoya-shi Aichi (JP)
Inventor: Ueda, Isao, No. 10, Shinko-dori, 1-chome,
Minami-ku Nagoya-shi Aichi (JP)
Inventor: Kawaguchi, Munetaka, No. 10,
Shinko-dori, 1-chome, Minami-ku Nagoya-shi Aichi (JP)
Inventor: Nakabayashi, Hirohiko, No. 10,
Shinko-dori, 1-chome, Minami-ku Nagoya-shi Aichi (JP)
Inventor: Yamamoto, Teruyuki, No. 10,
Shinko-dori, 1-chome, Minami-ku Nagoya-shi Aichi (JP)

⑯ Designated Contracting States: CH DE FR IT LI

⑰ Representative: Pearce, Anthony Richmond et al, Marks
& Clerk Alpha Tower Suffolk Street Queensway,
Birmingham B1 1TT (GB)

⑯ Enamelled wires.

⑰ An enamelled wire is disclosed which comprises an electrical conductor (1), one or more wire enamel coats (2) formed on said conductor and a lubricating wire enamel coat (3) formed on the outermost layer of said wire enamel coat. The lubricating wire enamel coat (3) is formed by applying and baking a wire enamel composition consisting essentially of a resin at least one molecule of which is terminated with a straight alkyl group having 21 or more carbon atoms.



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ENAMELED WIRES

The present invention relates to enameled wires having good self-lubricating properties.

Recently, manufacturers of electric apparatuses that use enameled wires have come to use high-speed automatic winding machines to increase the speed of the production line. The enameled wire is subjected to friction and other mechanical stresses during winding which causes the insulation coating to be damaged mechanically. If such damaged wire is assembled in an electric machine, layer shorting (short-circuiting between wires) occurs and the loss factor is increased to an undesirably high level. Therefore, to minimize the mechanical damage to the insulation coating, enameled wires having good self-lubricating properties have been demanded. Wires with self-lubricating properties are needed not only for use in connection with an automatic winder but also when enameled wires are inserted manually into a small slot in a motor.

On the other hand, to achieve energy saving, additional improvements in the efficiency of various motors and transformers are desired. This requirement is particularly great for motors to be immersed in refriger-

ants for coolers, air conditioners and refrigerators, and to meet this end, the space factor is increased by inserting more enameled wires into small slots in motors.

Since enameled wires themselves do not have good self-lubricating properties, a layer of various liquid lubricants such as liquid paraffin and refrigerator oil has been conventionally applied to the enameled wires. However, as more enameled wires are inserted into the small slot to reduce the amount of space needed and hence increase the efficiency of motors, many problems have arisen which cannot be solved by using a conventional enameled wire coated with liquid lubricants such as refrigerator oil. For one thing, liquid lubricants such as refrigerator oil do not have very high lubricating properties and slip properties. Accordingly, a great number of enameled wires cannot be easily inserted into a small slot, and if they are inserted with great force, the enamel coating is damaged mechanically which increases the chance of layer shorting. The low self-lubricating properties of the enameled wire causes another disadvantage in that even after the coil of enameled wire is inserted in the motor, the enamel coating is subjected to mechanical damage due to electromagnetic vibration. As a result of the mechanical damage, layer shorting occurs and the motor fails to

perform its function. Improving the self-lubricating properties of enameled wires by applying a large quantity of liquid lubricants has little effect. On the contrary, the use of such lubricants causes more dirt to collect 5 on the enameled wires and the bonding strength of adhesive tape used to fix the ends of the coil is adversely affected.

Attempts have been made to eliminate these defects by coating enameled wires with solid lubricants 10 such as solid paraffin and carnauba wax having better lubricating properties and slip properties than liquid lubricants. However, because most of the solid lubricants are insoluble or sparingly soluble in solvents, they are usually applied to the enameled wire from a 15 solution having a few percent of the lubricant dissolved in solvents such as petroleum benzine and xylene, and the solvent is subsequently evaporated. This method requires wasting a large quantity of solvents. Furthermore, the method requires a vapor scrubber to protect 20 the health of workers as well as a burner and other means to remove the discharged vapor and convert it into a harmless form. The use of solvents having low flash points presents a fire hazard; and a heating furnace is necessary for drying the applied wire enamel coating. 25 As a further defect, the solvent on the insulation coat-

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ing of some wires can cause creasing or crazing that makes the wires no longer acceptable as commercial products.

Therefore, the coating of solid lubricants can only be applied to limited types of electric wires. Furthermore,

5 the lubricant solution has such a low concentration and viscosity that the thickness of the lubricant coating cannot be controlled satisfactorily. All the operator can do is to simply pass the electric wire through the lubricant solution and let it deposit on the wire
10 surface. It is, therefore, very difficult to apply the lubricant solution in a controlled amount.

If the enameled wires having a coating of these solid lubricants are applied to motors to be immersed in refrigerants, the lubricant coating is extracted by the

15 refrigerant and can clog the opening of the compressor valve or the refrigerant expansion nozzles in the refrigerator. This will reduce the refrigerating capacity of the machine. In addition, if the lubricant is extracted by the refrigerant, the self-lubricating properties and
20 slip properties of the enamel wire are reduced and the enamel coating becomes vulnerable to mechanical damage due to electromagnetic vibration.

Another method that has been proposed for providing enameled wires with high self-lubricating

25 properties is to use wire enamel compositions containing

synthetic resins having good lubricating properties such as polyethylene, polypropylene and polytetrafluoroethylene, silicone oil, fluorine containing surfactants, and liquid as well as solid lubricants such as paraffin 5 wax, carnauba wax and montan wax. But synthetic resins such as polyethylene, polypropylene and polytetrafluoroethylene are sparingly soluble in wire enamel compositions and are difficult to disperse in the enamel uniformly, and the resulting enamel is not highly stable.

10 What is more, these polymers are not highly miscible with the components of the enamel so it is difficult to disperse them in the enamel coating uniformly and the resulting enamel coating does not have a good appearance. Liquid lubricants in the wire enamel composition provide

15 a wire enamel coating whose slip properties and self-lubricating properties are as low as those of the coating formed by applying them onto the enameled wire. Solid lubricants in the wire enamel composition are sometimes extracted by refrigerants or solvents after the wire

20 enamel is applied to the electric wire (the same thing happens when solid lubricants are directly applied to the enameled wire). Enameled wires so produced are not desirably applied to motors that are to be immersed in refrigerants. Furthermore, like synthetic resins, the

25 solid lubricants are sparingly soluble in solvents for

making wire enamel and they are not highly miscible with the insulating components of the enamel. Therefore, the resulting wire enamel is not stable and the lubricants are difficult to disperse in the enamel coating uniformly
5 and hence the so produced coating does not have good appearance.

SUMMARY OF THE INVENTION

As a result of various studies to eliminate the above defects of the conventional enameled wires,
10 the present inventors have found that a desired enameled wire can be produced by forming one or more wire enamel coatings on a conductor and a lubricating wire enamel coat on the outermost layer of said wire enamel coat that is made by applying and baking a wire enamel
15 composition consisting essentially of a resin at least one molecule of which is terminated with a straight alkyl group having 21 or more carbon atoms. The enamel wire of the present invention itself has self-lubricating properties equal to those of the wire that has a layer
20 of solid lubricants such as solid paraffin and carnauba wax, or those of the wire that is produced by coating the conductor with a wire enamel composition containing such solid lubricants or synthetic resins such as polyethylene and polypropylene having good lubricating
25 properties.

In the enameled wire of the present invention, the wire enamel coating itself has high self-lubricating properties. In this respect, the wire differs greatly from the conventional product wherein a lubricant is present on the surface of the enameled wire or within the wire enamel coat. The wire enamel composition used in the present invention is more stable and uniform than wire enamel compositions containing synthetic resins having good lubricating properties such as polyethylene and polypropylene, or solid lubricants such as solid paraffin and carnauba wax. Furthermore, the resulting enameled wire has a better appearance than those having a wire enamel coating made from the latter type of wire enamel. There is little chance that the wire enamel coating of the present invention will be extracted by refrigerants or solvents and clog the opening of the compressor valve or the refrigerant expansion nozzles in comparison with the wire enamel coating formed by applying solid lubricants such as solid paraffin or carnauba wax on the surface of the enameled wire or the coating formed from a wire enamel composition containing these solid lubricants. For these reasons, the enameled wire of the present invention can be applied with advantage to motors that are to be immersed in refrigerants and which are required to have high refrigerant resistance.

BRIEF DESCRIPTION OF THE DRAWING

Figure 1 is a cross section of the insulated electric wire of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

5 The enameled wire of the present invention comprises a conductor, one or more wire enamel coatings formed on the conductor, and a lubricating wire enamel coat formed on the outermost layer of said wire enamel coat. It is essential for the present invention that
10 the lubricating wire enamel coat be formed on the outermost layer of the one or more wire enamel coatings on the conductor. If the lubricating wire enamel coat is formed directly on the conductor, the desired mechanical characteristics may not be obtained. The proportion of
15 the lubricating wire enamel coat to the total thickness of the coating on the conductor is preferably as small as possible to avoid any adverse effect on the mechanical characteristics of the resulting enameled wire.

20 A wire enamel coat is usually formed on the conductor by 3 to 20 cycles of application and baking of the wire enamel until a coating of desired thickness is formed. Therefore, the best way to minimize the proportion of the wire enamel coat to the total thickness of the coating is to effect only the last cycle of application and baking using a wire enamel composition for
25

making the lubricating wire enamel coat. For achieving the desired mechanical characteristics, the thickness of the lubricating wire enamel coat is preferably not more than 20% of the total thickness of the coating on the 5 resulting enameled wire.

The wire enamel coat formed as a base coat in the enameled wire of the present invention may be made of any material such as polyurethane, polyvinyl formal, polyester, polyester imide, polyhydantoin, polyamide-imide, polyimide, polyester amideimide and polyamide. 10

These resins may be combined in the form of, say, polyurethane-polyamide, polyester-polyamide, polyester-polyamideimide, polyester imide-polyamideimide, and polyimide-polyvinyl formal. Since the enameled wire of 15 the present invention may be applied to motors to be immersed in refrigerants, the base wire enamel coat is preferably made of vinyl formal, polyester, polyester imide, polyamideimide, polyester amideimide and polyimide, and mixtures thereof.

20 The lubricating wire enamel coat formed as a top coat in the enameled wire of the present invention is formed by applying and baking a wire enamel composition that consists essentially of a resin at least one molecule of which is terminated with a straight alkyl 25 group having 21 or more carbon atoms and preferably

27 to 31 carbon atoms. The polymer backbone may be bonded to the terminal straight alkyl group in any fashion such as amido bond, imido bond, ester bond, urethane bond or urea bond. The straight alkyl group 5 bonded to a terminal of the polymer chain must have at least 21 carbon atoms to provide good lubricating properties, and the desired lubricating properties are not achieved if said alkyl group has less than 21 carbon atoms. Briefly stated, if the terminal is represented 10 by $\{CH_2\}_{n-1}CH_3$, n must be 21 or more. The alkyl group is preferably in a completely linear form, but it may be partially branched as long as the straight portion has at least 21 carbon atoms.

The polymer chain to a terminal of which the 15 straight alkyl group having 21 or more carbon atoms is to be attached may be made of any resin such as polyamideimide, polyimide, polyester, polyester imide, polyurethane, polyester amideimide, polyamide or polyhydroxyether. Two typical methods of introducing the 20 straight alkyl group having 21 or more carbon atoms at a terminal of the molecule of these resins are 1) reacting the materials for preparing the polymer chain of the resin to be produced with a compound that is described hereunder and which is used to introduce the straight 25 alkyl group having 21 or more carbon atoms at a terminal

of the molecule of the resin, so as to form the polymer chain and introduce the straight alkyl group at the terminal of its molecule, and 2) reacting the materials for preparing the polymer chain among themselves, then 5 depolymerizing the resulting resin with a compound that is used to introduce the straight alkyl group having 21 or more carbon atoms at a terminal of its molecule so as to introduce said alkyl group at the terminal.

Examples of the compound that is used to 10 introduce a straight alkyl group having 21 or more carbon atoms at a terminal of the molecule of the resin used to form the lubricating wire enamel coat include aliphatic acids, alkyl esters and acid halides thereof, as well as higher alcohols, amines and aliphatic acid amides.

15 Illustrative examples of aliphatic acids include docosanoic acid, tricosanoic acid, tetracosanoic acid, pentacosanoic acid, hexacosanoic acid, heptacosanoic acid, octacosanoic acid, nonacosanoic acid and triacontanoic acid, and derivatives of these aliphatic 20 acids are esters, acid anhydrides and acid halides.

Illustrative examples of higher alcohols include n-heneicosanol, n-docosanol, n-tetracosanol, n-hexacosanol, n-octacosanol, and n-triacontanol. Illustrative examples of amines include heneicosylamine, docosylamine, 25 tricosylamine, pentacosylamine, hexacosylamine, and

octacosylamine. Illustrative examples of aliphatic acid amides include docosylamide, hexacosylamide and octacosylamide. It is, of course, necessary that if these compounds are used to introduce the straight alkyl group at a terminal of the polymer chain, they should have functional groups that are capable of reacting with the materials used to prepare the polymer chain. These compounds need not be used individually and may be used in admixture. For instance, Hoechst Wax S sold by Hoechst Japan Ltd. that is based on montan wax acid (chain length: C 28-32), Hoechst Wax E (ester of montan wax acid) or Hoechst Wax OP (partially saponified ester of montan wax acid) also sold by Hoechst Japan Ltd. may be used.

Any solvent can be used to dissolve the resin at least one molecule of which is terminated with a straight alkyl group having 21 or more carbon atoms. When preparing a wire enamel composition, preferred solvents are those which consist essentially of N-methyl-2-pyrrolidone, N,N-dimethylacetamide, m-cresol, p-cresol and various xlenols because the resulting polymer solution can be directly used as wire enamel for making enameled wires. Suitable solvents that can be used to control the viscosity of the polymer solution are toluene, xylene, solvent naphtha, acetone, methyl ethyl ketone, cyclohexanone and Cellosolve acetate.

The wire enamel composition according to the present invention which consists essentially of a resin at least one molecule of which is terminated with a straight alkyl group having 21 or more carbon atoms is either a polymer solution per se of the resin at least one molecule of which is terminated with a straight alkyl group having 21 or more carbon atoms, or such polymer solution that contains one or more additives such as other thermoplastic resins, thermosetting resins, curing agents, fillers, pigments and dyes in an amount that does not impair the characteristics of said solution.

The polymer solution per se is preferred.

The present invention is now described in greater detail by reference to the following examples and comparative examples which are given here for illustrative purposes only and are by no means intended to limit its scope. Unless otherwise noted, all reactions were performed in the following reference examples under thorough stirring in a reaction vessel having a 3 liter capacity four-necked flask equipped with a cooling tube, a fractionating column, a thermometer and a stirrer. The reaction vessel was heated with a mantle heater. Baking of the polymer solution coated wires was carried out in a vertical furnace at a furnace temperature of 360°C in the top, 320°C in the middle and 260°C in the

bottom as the wire was supplied at a linear speed of 15 m/min. All characteristics except the coefficient of static friction of the enameled wires prepared were measured in accordance with JIS C3003. The coefficient of static friction was measured by the following method in terms of the coefficient of static friction between enameled wires: two parallel enameled wires were placed on a horizontal plane; a metal block to the bottom of which two parallel enameled wires were fastened was placed on said horizontal plane so that the respective pairs of wires crossed each other at a right angle; the metal block was moved along the two wires on the horizontal plane; and the minimum load necessary for moving the block was divided by the weight of the block to determine the coefficient of static friction of the wires.

REFERENCE EXAMPLE 1

Diphenylmethane-4,4'-diisocyanate (500.5 g) was gradually added to a mixture of trimellitic anhydride (384.3 g) and N-methyl-2-pyrrolidone (1,653.8 g) under stirring, and the resulting mixture was heated at 80°C for 3 hours. Thereafter, the temperature of the reaction mixture was increased at a rate of 20°C per hour. During the reaction, the viscosity of the solution gradually increased, accompanied by the generation of carbon dioxide gas. When the temperature of the reaction

mixture reached 160°C, the heat was removed, and the reaction was continued at that temperature for 2 more hours until a polyamideimide polymer solution was obtained. The polymer had a reduced specific viscosity of 0.38 dl/g as measured at 30°C in 100 ml of N,N'-dimethylacetamide having 0.5 g of the resin dissolved. The polymer solution was diluted with xylol to form a wire enamel composition having a resin content of 25%. The wire enamel had a viscosity of 17 poises as measured with a Brookfield type viscometer at 30°C.

REFERENCE EXAMPLE 2

Diphenylmethane-4,4'-diisocyanate (500.5 g) was gradually added to a mixture of trimellitic anhydride (381.2 g), Hoechst Wax S (14.1 g, montan wax acid having a chain length of 28 to 32 from Hoechst Japan Ltd.) and N-methyl-2-pyrrolidone (1,679.8 g) under stirring, and the resulting mixture was heated at 80°C for 3 hours. Thereafter, the reaction mixture was heated at a rate of 20°C per hour. When the temperature of the reaction mixture reached 170°C, the heat was removed, and the reaction was continued at that temperature for 1.5 hours until a polyamide resin solution wherein at least one molecule of the resin was terminated with a straight alkyl group having 27 to 31 carbon atoms was obtained. The resin had a reduced specific viscosity of 0.49 dl/g.

The resin solution was diluted with xylol to form a wire enamel composition having a resin content of 25%. The wire enamel had a viscosity of 38 poises.

REFERENCE EXAMPLE 3

5 Diphenylmethane-4,4'-diisocyanate (500.5 g) was added to a mixture of trimellitic anhydride (382.4 g), docosanoic acid (6.8 g) and N-methyl-2-pyrrolidone (1,667.0 g) under stirring and the resulting mixture was heated to 80°C where it was subjected to reaction for 3
10 hours. Thereafter, the reaction mixture was heated at a rate of 20°C per hour. When the temperature reached 175°C, the heat was removed and the reaction was further continued for 1 hour and 45 minutes until a polyamide-imide resin solution wherein at least one molecule of
15 the resin was terminated with a straight alkyl group having 21 carbon atoms was obtained. The resin had a reduced specific viscosity of 0.70 dl/g. The solution was diluted with xylol to form a wire enamel composition having a resin content of 25%. The wire enamel had a
20 viscosity of 60 poises.

REFERENCE EXAMPLE 4

The following components were charged in a flask.

	Dimethyl terephthalate	388.4 g (2.0 moles)
5	Ethylene glycol	95.1 g (1.5 moles)
	Glycerol	92.1 g (1.0 mole)
	Lead acetate	0.8 g
	Xylene	300.0 g

Under stirring, the mixture was gradually heated to 140°C at which temperature it was subjected to reaction for 2 hours. It was then heated so that its temperature increased at a rate of 20°C per hour. Throughout the reaction, xylene and by-products were distilled out of the reaction system through the cooling tube. The viscosity of the mixture increased gradually. When the temperature of the mixture reached 240°C, the flask was evacuated and the reaction was continued at that temperature. The viscosity of the mixture increased further. Thirty minutes after the evacuation of the flask started, the pressure in the flask was returned to atmospheric and the heat was removed. Cresol was added to achieve a resin content of 40% and to dissolve the resin in cresol. Two percent by weight each of tetrabutyl titanate and zinc octanoate (based on the resin) was added to make a polyester wire enamel composition. The wire enamel had a viscosity of 72 poises.

REFERENCE EXAMPLE 5

The following components were charged in a flask.

	Dimethyl terephthalate	388.4 g (2.0 moles)
5	Ethylene glycol	93.1 g (1.5 moles)
	Glycerol	92.1 g (1.0 mole)
	Methyl behenate	13.2 g
	Lead acetate	0.8 g
	Xylene	300.0 g

10 The mixture was treated as in Reference Example 4 to produce a polyester wire enamel composition wherein at least one molecule of the polymer was terminated with a straight alkyl group having 21 carbon atoms. The enamel had a viscosity of 69 poises.

15 REFERENCE EXAMPLE 6

	Dimethyl terephthalate	388.4 g (2.0 moles)
	Ethylene glycol	186.0 g (3.0 moles)
	Glycerol	184.2 g (2.0 moles)
	Lead acetate	0.8 g
20	Xylene	300.0 g

Under stirring, the temperature of the mixture was elevated to 140°C at which temperature the mixture was subjected to reaction for 1.5 hours. The temperature was further increased at a rate of 20°C per hour. When the 25 temperature reached 200°C, the reaction was further

continued for one hour at that temperature. Throughout the reaction, xylene and by-product (methanol) were distilled out of the reaction system through the cooling tube. Then, the mixture was cooled to 110°C and the 5 following compounds were added to the reaction mixture:

4,4'-Diaminodiphenylmethane 396.5 g (2.0 moles)

Trimellitic anhydride 768.5 g (4.0 moles)

When the temperature of the mixture was increased again, a yellow precipitate was formed at about 120°C and the 10 mixture solidified. Then, the mixture was held at 140°C for 30 minutes without stirring, and thereafter, it was heated to 180°C over about one hour. Throughout the reaction, water that was produced as a by-product was distilled out of the reaction system through the cooling 15 tube. Since the mixture became somewhat fluid, it was heated to 230°C over one hour under stirring, whereupon it became transparent and its viscosity increased gradually. The reaction was continued at 230°C for 2 hours, and after the interior of the flask was evacuated, 20 the reaction was further continued for one hour. Then, the pressure in the flask was returned to atmospheric and immediately thereafter, cresol was added to achieve a resin content of about 35%. The reaction was discontinued and the mixture was dissolved in cresol. Two parts 25 by weight each of tetrabutyl titanate and zinc octanoate

(per 100 parts by weight of the resin) was added to make a polyester imide wire enamel composition, which had a viscosity of 30 poises.

REFERENCE EXAMPLE 7

5 The following components were charged in a flask:

	Dimethyl terephthalate	388.4 g (2.0 moles)
	Ethylene glycol	186.2 g (3.0 moles)
	Glycerol	184.2 g (2.0 moles)
10	Hoechst Wax E	87.6 g
	Lead acetate	0.8 g
	Xylene	300.0 g

Under stirring, the temperature of the mixture was elevated to 140°C at which temperature it was subjected 15 to reaction for 1.5 hours. The temperature was further increased at a rate of 20°C per hour. When the temperature reached 200°C, the reaction was further continued for one hour at that temperature. Throughout the reaction, xylene and by-product methanol were distilled out 20 of the reaction system through the cooling tube. Then, the mixture was cooled to 110°C and the following compounds were added to the reaction mixture:

	4,4'-Diaminodiphenylmethane	396.5 g (2.0 moles)
	Trimellitic anhydride	768.5 g (4.0 moles)
25	When the temperature of the mixture was increased again, a yellow precipitate was formed at about 120°C and the	

mixture solidified. Then, the mixture was held at 140°C for 30 minutes without stirring, and thereafter, it was heated to 180°C over about one hour. Throughout the reaction, water that was produced as a by-product was 5 distilled out of the reaction system through the cooling tube. Since the mixture became somewhat fluid, it was heated to 230°C over one hour under stirring, whereupon it became transparent and its viscosity increased gradually. The reaction was continued at 230°C for 2 hours, and 10 after the interior of the flask was evacuated, the reaction was further continued for one hour. Then, the pressure in the flask was returned to atmosphere and immediately thereafter, cresol was added to achieve a resin content of about 35%. The reaction was discontinued and 15 the mixture was dissolved in cresol. Two parts by weight each of tetrabutyl titanate and zinc octanoate (per 100 parts by weight of the resin) was added to make a polyester imide wire enamel composition wherein at least one molecule of the polymer was terminated with a straight 20 alkyl group having 27 to 31 carbon atoms. The wire enamel had a viscosity of 44 poises.

COMPARATIVE EXAMPLES 1 TO 9 AND EXAMPLES 1 TO 6

The wire enamel compositions of Reference Examples 1 to 7 and two commercial products were applied 25 to copper conductors and baked according to the formulations indicated in Table 1 to produce insulated electric wires. The characteristics of the wires are also indicated in Table 1.

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TABLE 1

<u>Undercoat Enamel</u>	<u>Comp. Ex. 1</u>	<u>Comp. Ex. 2</u>	<u>Ex. 1</u>	<u>Ex. 2</u>	<u>Comp. Ex. 3</u>
	AI (Ref. Ex.1)	AI (Ref. Ex.2)	AI (Ref. Ex.1)	AI (Ref. Ex.1)	AI (Ref. Ex.6)
Enamel used	---	---	---	---	---
Terminal straight alkyl group having 21 or more carbon atoms	---	---	Present	Absent	Absent
<u>Overcoat Enamel</u>					
Enamel used	---	---	AI (Ref. Ex.2)	AI (Ref. Ex.7)	---
Terminal straight alkyl group having 21 or more carbon atoms	---	---	Present	Present	---
<u>Number of Coating and Baking Cycles (undercoat/overcoat)</u>	<u>7/0</u>	<u>7/0</u>	<u>6/1</u>	<u>7/1</u>	<u>7/0</u>
<u>Conductor Diameter (mm)</u>	1.000	1.000	1.000	0.999	0.999
<u>Undercoat Thickness (mm)</u>	0.025	0.024	0.0215	0.024	0.035
<u>Overcoat Thickness (mm)</u>	---	---	0.003	0.002	---
<u>Thickness Ratio (%)</u>	---	---	12.2	2.7	---
<u>Flexibility at 20% Rapid Elongation</u>	2d	3d	2d	2d	1d
<u>Repeated Scrape Test (times)</u>	177	95	175	151	51
<u>Coefficient of Static Friction</u>	0.24	0.05	0.05	0.07	0.23

TABLE 1 (continued)

Comp. Ex. 4	Comp. Ex. 5	Ex. 3	Ex. 4	Comp. Ex. 6
<u>Undercoat Enamel</u>				
Enamel used	EI (Ref. Ex.7)	EI (Commercial Product A)	EI (Commercial Product A)	EI (Commercial Product A)
Terminal straight alkyl group having 21 or more carbon atoms	Present	Absent	Absent	Absent
<u>Overcoat Enamel</u>				
Enamel used	---	---	EI (Ref. Ex.7)	EI (Ref. Ex.1)
Terminal straight alkyl group having 21 or more carbon atoms	---	---	Present	Present
Number of Coating and Baking Cycles (undercoat/overcoat)	7/0	7/0	6/1	5/1
Conductor Diameter (mm)	0.999	0.999	0.999	0.999
Undercoat Thickness (mm)	0.036	0.035	0.029	0.0275
Overcoat Thickness (mm)	---	---	0.005	0.006
Thickness Ratio (%)	---	---	14.7	19.6
Flexibility at 20% Rapid Elongation	2d	1d	1d	1d
Repeated Scrape Test (times)	28	34	77	70
Coefficient of Static Friction	0.06	0.28	0.08	0.09

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TABLE 1 (continued)

	Ex. 5	Comp. Ex. 7	Comp. Ex. 8	Comp. Ex. 9	Ex. 6
<u>Undercoat Enamel</u>					
Enamel used	ET (Commercial Product A)	PE (Ref. Ex.4)	PE (Ref. Ex.5)	PE (Commercial Product B)	PE (Commercial Product B)
Terminal straight alkyl group having 21 or more carbon atoms	Absent	Absent	Present	Absent	Absent
<u>Overcoat Enamel</u>					
Enamel used	AI (Ref. Ex.3)	--	--	--	PE (Ref. Ex.5)
Terminal straight alkyl group having 21 or more carbon atoms	Present	--	--	--	Present
Number of Coating and Baking Cycles (undercoat/overcoat)	8/1	6/0	6/0	6/0	5/1
Conductor Diameter (mm)	1.000	0.998	0.998	0.998	0.998
Undercoat Thickness (mm)	0.034	0.033	0.0355	0.036	0.0285
Overcoat Thickness (mm)	0.003	--	--	--	0.0055
Thickness Ratio (%)	8.2	--	--	--	16.2
Flexibility at 20% Rapid Elongation	2d	1d	2d	1d	1d
Repeated Scrape Test (time)	98	53	18	48	54
Coefficient of Static Friction	0.11	0.22	0.06	0.26	0.07

Notes:

AI = Polyamideimide resin

EI = Polyester imide resin

PE = Polyester resin

5 Commercial Product A = Isomid from Nisshoku-Schenectady Co., Ltd.

Commercial Product B = Delacoat E 220G from Nitto Electric Industrial Co., Ltd.

Thickness Ratio (%) = $\frac{\text{Thickness of Overcoat}}{\frac{\text{Thickness of Undercoat} + \text{Thickness of Overcoat}}{\text{Thickness of Overcoat}}} \times 100$

10 Table 1 clearly shows that the enameled wires of the present invention had far better self-lubricating properties than the conventional products. In addition, the enameled wires of the present invention had better mechanical characteristics than the samples of Comparative Examples 2, 4 and 8 wherein the wire enameled coating was entirely made of the lubricating wire enamel coat.

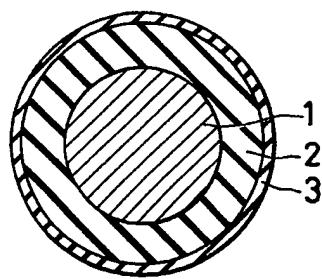
15 While the invention has been described in detail and with reference to specific embodiments thereof, it will be apparent to one skilled in the art 20 that various changes and modifications can be made therein without departing from the spirit and scope thereof.

C L A I M S

1. An enameled wire comprising an electrical conductor, a wire enamel coat formed on said electrical conductor and a lubricating wire enamel coat formed on
5 said wire enamel coat, said lubricating wire enamel coat being formed by applying and baking a wire enamel composition consisting essentially of a resin at least one molecule of which is terminated with a straight alkyl group having 21 or more carbon atoms.
- 10 2. An enameled wire as claimed in Claim 1, wherein said lubricating wire enamel coat is formed by a single cycle of application and baking of a wire enamel composition consisting essentially of a resin at least one molecule of which is terminated with a
15 straight alkyl group having 21 or more carbon atoms.
3. An enameled wire as claimed in Claim 1, wherein the thickness of the lubricating insulation coat is not more than 20% of the total thickness of the wire enamel coating of the wire..
- 20 4. An enameled wire as claimed in Claim 1, 2, or 3, further comprising an additional wire enamel coat on said wire enamel coat, said additional wire enamel coat being the outermost wire enamel coat and being coated with said lubricating wire enamel coat.

5. An enameled wire as claimed in
Claim 1, 2 or 3, further comprising a plurality of
additional wire enamel coats on said wire enamel coat,
the outermost of said plurality of additional wire
5 enamel coats being coated with said lubricating wire
enamel coat.

FIG. 1





DOCUMENTS CONSIDERED TO BE RELEVANT			CLASSIFICATION OF THE APPLICATION (Int. Cl. 3)
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	
X	EP - A1 - 0 033 224 (SUMITOMO) * Page 38, claim 1; pages 30-35, examples 11,12 *	1-5	H 01 B 7/02 C 09 D 5/25
			TECHNICAL FIELDS SEARCHED (Int. Cl. 3)
			H 01 B 7/00 C 09 D 5/00 C 09 D 3/00
			CATEGORY OF CITED DOCUMENTS
			X: particularly relevant if taken alone Y: particularly relevant if combined with another document of the same category A: technological background O: non-written disclosure P: intermediate document T: theory or principle underlying the invention E: earlier patent document, but published on, or after the filing date D: document cited in the application L: document cited for other reasons B: member of the same patent family, corresponding document
X	The present search report has been drawn up for all claims		
Place of search	Date of completion of the search	Examiner	
VIENNA	27-10-1982	KUTZELNIGG	